Australian Government

ANSTO

What is radiation?

Science. Ingenuity. Sustainability.

Introduction to radiation

What is radiation?

Radiation can be described as energy or particles from a source that travel through space or other mediums. Light, heat, microwaves and wireless communications are all forms of radiation. The kind of radiation discussed here is called ionising radiation because it can produce charged particles (ions) in matter.

Ionising radiation is emitted by a large range of natural materials, can be produced by everyday devices such as X-ray machines, and can also be emitted by unstable atoms. Atoms become unstable when they have the wrong amount of mass required to keep them stable, an excess of energy, or both. Unstable atoms are said to be radioactive.

In order to reach stability these atoms give off, or emit, energy and/or mass. The energy is emitted in the form of electromagnetic radiation (i.e. light) and the mass is in the form of tiny particles. These emissions are called nuclear radiation and such atoms are said to be radioactive.

Gamma radiation is an example of electromagnetic radiation. Beta and alpha radiation are examples of emitted particles. Ionising radiation can also be produced by devices such as X-ray machines.

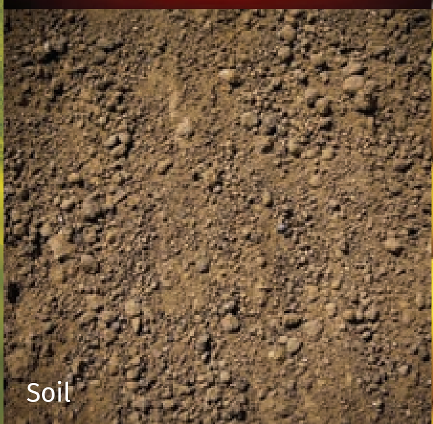
IN AUSTRALIA THE AVERAGE BACKGROUND RADIATION DOSE IS APPROXIMATELY 1.5 mSv PER YEAR

Sources of naturally occurring ionising radiation


The Sun


Rocks


Buildings


Soil


Food


Humans

Radiation doses

Ionising radiation and radioactive materials are widely used in medicine, industry, agriculture, environmental studies, pollution control and research. These uses benefit each of us individually and the Australian community as a whole.

Humans have increased their radiation dose through a variety of activities. One is living indoors. In surrounding ourselves with bricks and mortar, we increase the concentration of a radioactive gas called radon in the air we breathe. Radon arises naturally from the radioactive decay of uranium and thorium, normally present in rocks, soil, bricks, mortar, tiles and concrete.

Reducing ventilation in order to conserve energy may increase radon concentrations even further. Using bore water, especially in a hot shower or in thermal springs, also increases your radiation dose.

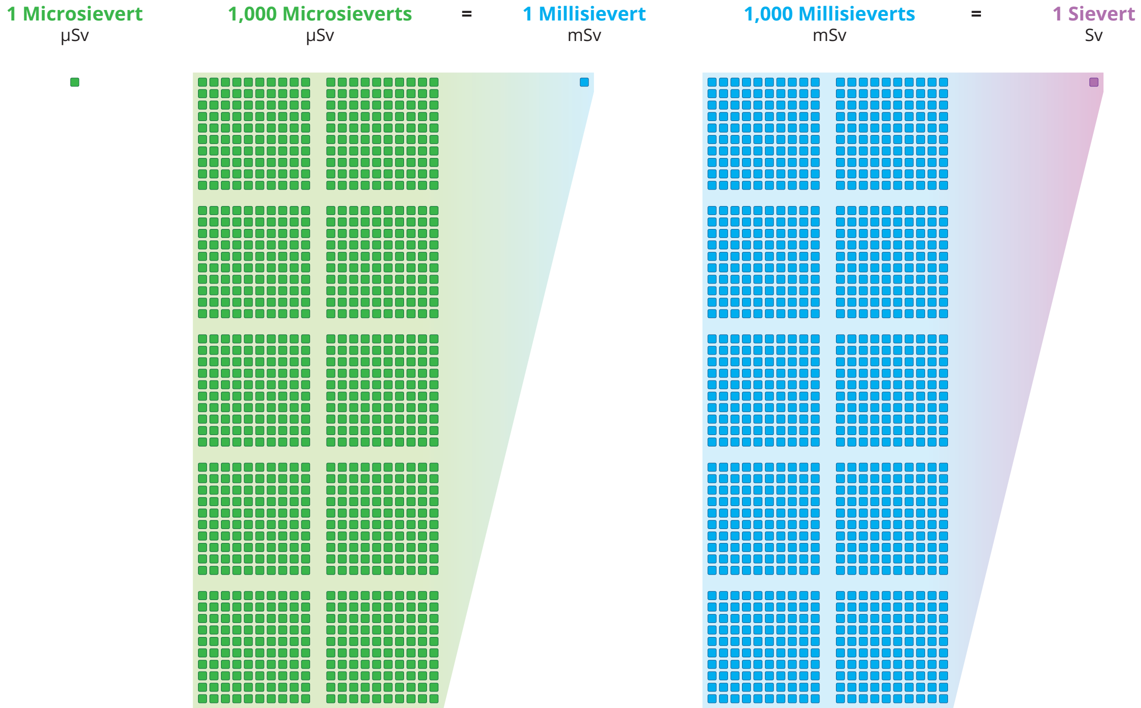
Another source of radiation is medical use –X-rays in radiography and tomography and radioactivity in nuclear medicine. Some therapeutic uses of radiation give a dose to certain organs many times higher than our annual background radiation dose.

Small extra doses of radiation occur in a number of ways. The higher you go, the less shielding the atmosphere affords from cosmic rays. On a mountain top the air may be cleaner, but the radiation dose is higher. Air travel increases radiation dose; astronauts receive even higher doses. Fallout from atmospheric nuclear testing in the 1950s and 1960s is still present in the environment. Many industries release otherwise locked-in radioactivity into the environment. This is especially true of a coal-burning plant, and to a lesser extent the fertiliser, mining and building industries.

Other common, but minor, sources of radiation are some older luminescent clocks, watches, compasses and gunsights, exit signs, certain paints and pigments, dental porcelain, fire alarms and smoke detectors.

Although some radiation is capable of travelling large distances, it may be stopped by appropriate absorbers. Starlight traverses galaxies, but may be stopped by a piece of paper. Radio waves, too, are capable of travelling great distances, but may be absorbed by materials such as metals. Like light, ionising radiation travels in straight lines until absorbed or deflected. The material used to absorb ionising radiation depends on the type and energy of the radiation.

Units of ionising radiation dose



Exposure to ionising radiation is measured in units called the Sievert (Sv). The Sv is quite a large unit so it is normal to measure exposures in mSv (thousandths of a Sv) or μSv (millionths of a Sv).

Cancer risk

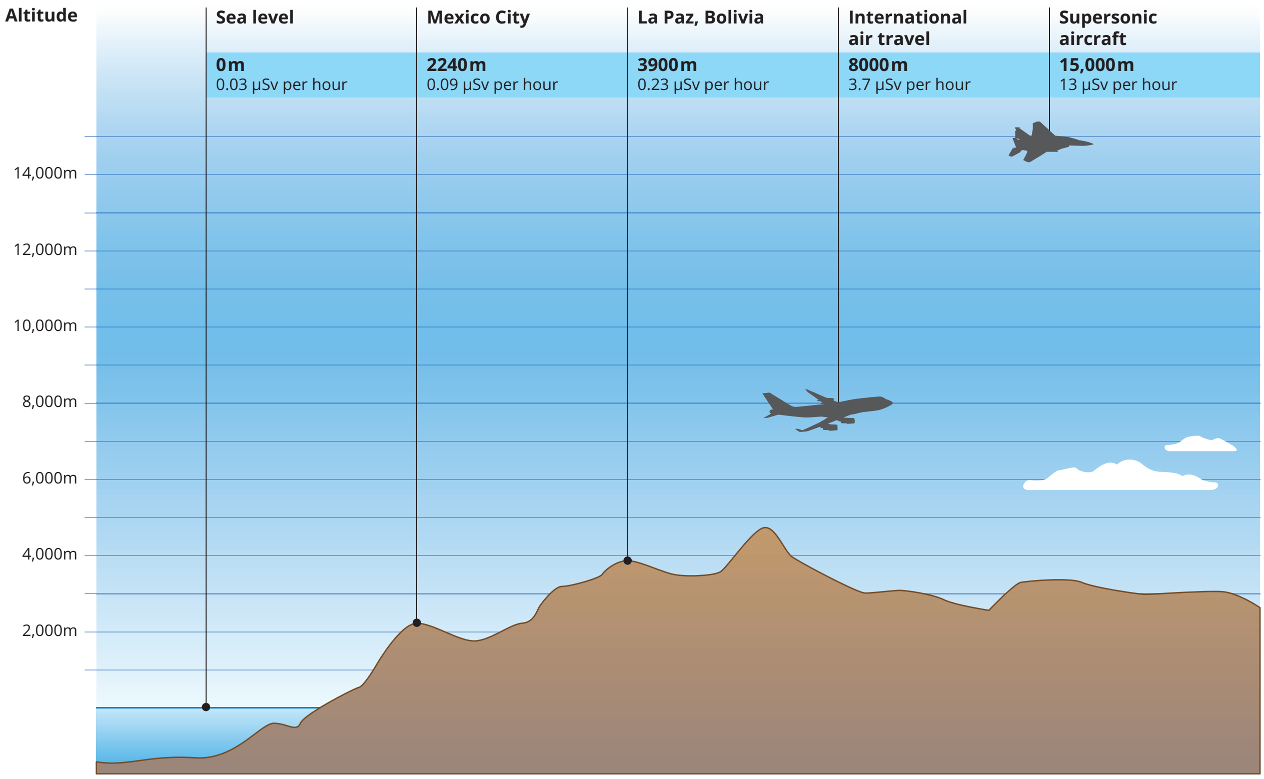
Risk estimates for cancer following exposure to ionising radiation are the subject of ongoing detailed studies. Existing estimates are based largely on information of the cancer rates in groups of people subjected to large size single or multiple doses of radiation given quickly.

Present evidence indicates that the damaging after-effects of radiation exposure are greatly reduced when the dose is delivered in small amounts spread over a long time period. Nevertheless, for the purposes of radiation protection, it is assumed that any radiation dose, however small, can have some effect and protective measures are put in place for radiation workers.

International studies of large groups of workers in the nuclear industry (who receive low doses spread over several years) generally agree with existing risk estimates.

There are a number of locations in the world in countries such as Brazil, India, China, France and Russia where the external natural background exposure is very high, being 10 to 15 times the Australian level. Studies in these areas have detected no increases in cancer rates.

Cosmic radiation dose rates at different altitudes



Cosmic radiation dose rates at different altitudes.

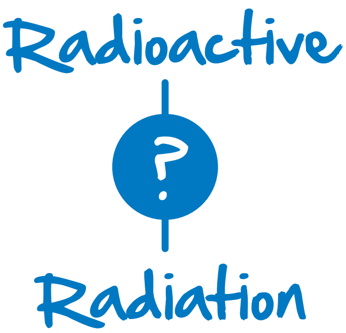
Question & Answer

Q. What is radiation?

A. Radiation includes electromagnetic radiation (such as light and heat, microwaves, radiowaves, ultra- violet, X-rays and gamma rays) and particles (such as alpha, beta and neutrons) which are emitted by some materials and carry energy. X-rays, γ-rays, α particles, β particles and neutrons are examples of ionising radiation.

Q. What is the difference between radiation and radioactivity?

A. A radioactive atom is unstable because it contains extra energy. When this atom 'decays' to a more stable atom, it releases this extra energy as ionising radiation.

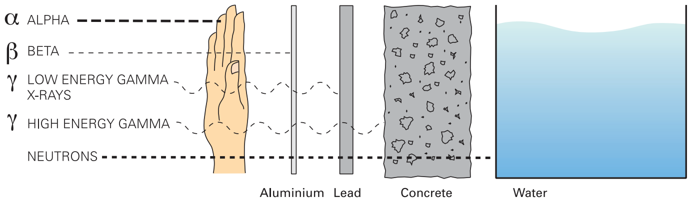


Q. How is ionising radiation different from other types of radiation?

A. Ionising radiation can knock electrons out of atoms, either by direct interaction with the atoms or by other methods. Alpha and beta particles, X-rays and gamma rays are examples of directly ionising radiation, while neutrons cause ionisation by indirect processes.

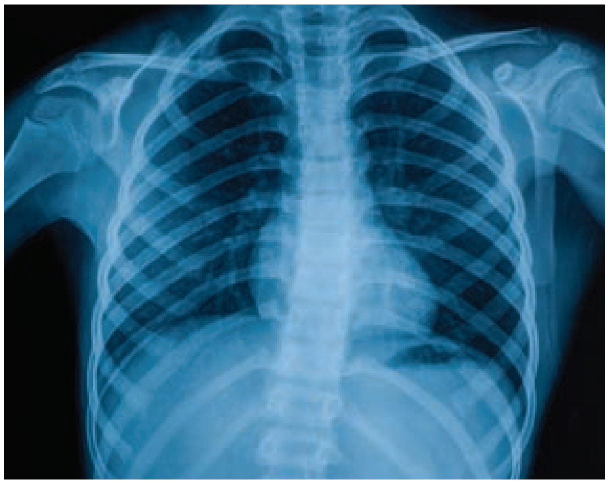
Q. Is there more than one kind of ionising radiation?

A. Yes. In addition to X-rays, three are common. They are called alpha, beta and gamma. Alpha particles (helium nuclei) may be stopped by paper, beta rays (high speed electrons) are stopped by perspex, while gamma rays (like X-rays) may need lead or concrete to stop them, but can be stopped by any material, even water, providing there is enough of it.



Q. Will these ionising radiations make me radioactive?

A. No, just as light will not make you glow in the dark and a chest X-ray will not make you radioactive.



Q. If ionising radiation does not make things radioactive, how do items become radioactive in a reactor?

A. In a reactor there are billions of free nuclear particles called neutrons. When absorbed by a material they may make it radioactive, i.e. it emits its own radiation. This is how radioisotopes are made.

Q. But surely radiation builds up in the body until it gets to a point where it kills you?

A. Ionising radiation does not build up in your body any more than light which falls on you builds up.

The radiation that reaches you is gone a fraction of a second later. Radiation effects may appear following exposure to high doses in a short time, just as a bad dose of sunburn results from too much exposure to sunlight too quickly. Similarly, long term exposure to ionising radiation at high levels may cause permanent damage to the body.

National and international dose limits for occupationally exposed workers and members of the public are many times lower than these high levels. In addition, the goal of radiation protection is to keep long term environmental exposure, above normal background radiation, to a minimum.

Q. Well, if radiation does not build up within the body, how does it harm a person?

A. Radiation carries energy which may damage living cells in the same way as tobacco smoke, asbestos or ultraviolet light. If the dose is low or is delivered over a long time there is an opportunity for the body cells to repair. There is only a very small chance that some cells may have been damaged in such a way that effects such as cancer appear in later life.

Q. Where does my annual radiation dose come from?

A. Mainly from the decay of natural radioactivity in the earth, mostly from uranium and thorium. This gives rise to a radioactive gas called radon in the air we breathe. Radon is in all buildings. Smaller and roughly equal parts of everyday radiation come from cosmic rays and from the natural radioactivity of our food and drink. Some radiation is man-made.

Q. What are man-made sources of my radiation dose?

A. Medical uses of ionising radiation are the major items. These include the use of X-rays and radioactivity in nuclear medicine.

Question & Answer

Q. Can you put some figures on these natural background and man-made radiation doses?

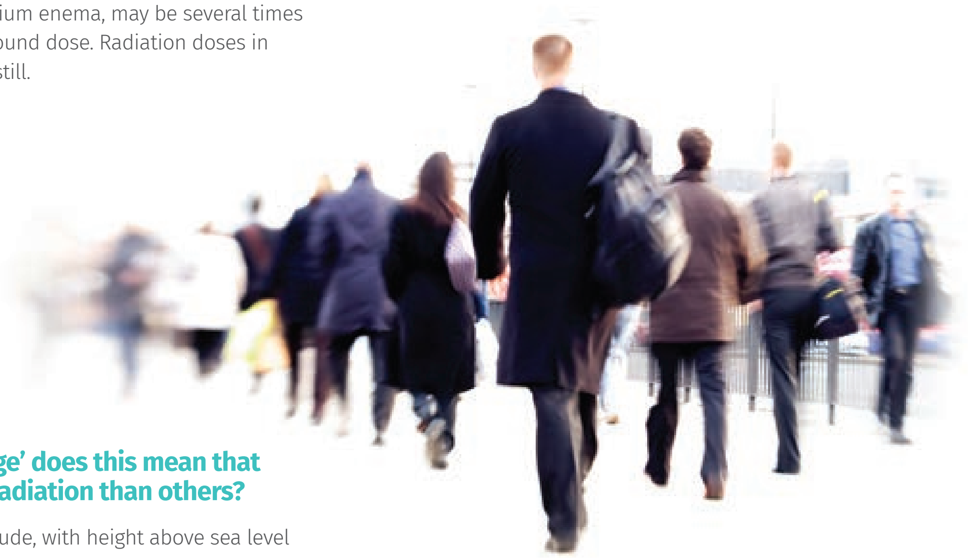
A. On average, Australians receive 1500 µSv a year from natural background radiation. Your additional dose from the medical use of radiation would depend on your medical history. The dose from a chest X-ray would be very small, about 1.5 per cent of the annual dose due to natural background radiation, while multiple X-rays, in conjunction with barium enema, may be several times larger than the annual background dose. Radiation doses in cancer therapy may be larger still.

Q. When you say 'on average' does this mean that some people get more radiation than others?

A. Yes. Cosmic rays vary with altitude, with height above sea level and with sun spot activity. Some rocks, like granite, and beach sands are more radioactive than other parts of the earth. Some foods, like olives and brazil nuts, accumulate more radioactivity than others. But the most important variation is in varying radon levels, brought about by differences in building materials, ventilation and water supplies.

Q. Surely it is dangerous for anyone to experience these higher levels of radiation dose?

A. When whole populations exposed to high background doses are compared to those exposed to low background doses, health differences are not detected. The human race has evolved over millions of years in this radioactive environment.



Q. How much does ANSTO's operations contribute to the radiation doses of nearby residents?

A. The dose that a member of the community living near ANSTO would receive from our operations is very small. Those people living close to the bushland perimeter (which extends to 1.6km from the reactor) would receive less than 10 µSv per year. This is only 0.7 per cent of the average natural background radiation in Australia.

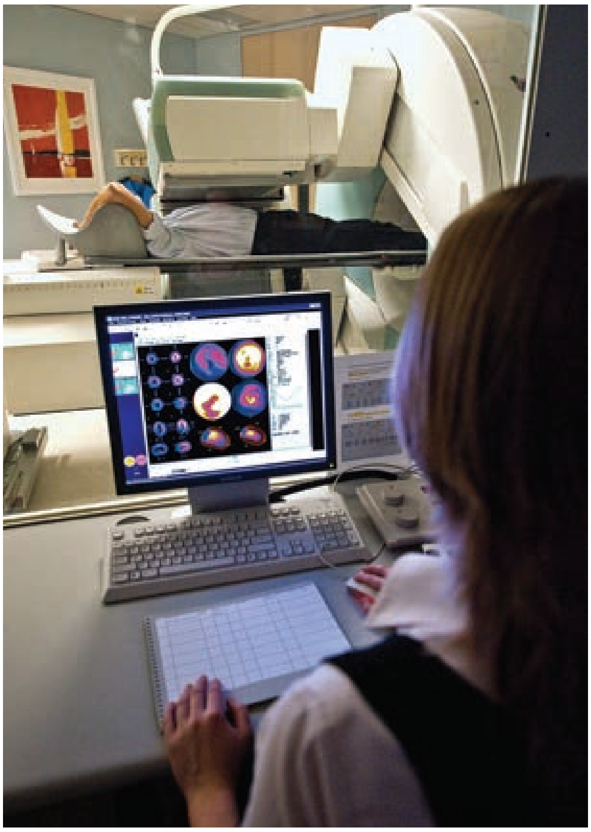
People living further away would receive proportionately less. This 10 µSv maximum dose is about the same as the dose received fromcosmic rays during a return flight between Sydney and Melbourne.

Q. If I get a radiation dose more quickly will it do more damage?

A. Yes, over an extended period, the body can repair most small damage from almost any cause, including radiation. But if the dose is acute, that is, all received in one short period, more serious damage may occur.

Q. What kinds of radiation damage can occur?

A. There are two kinds: damage to the cells of your body, which may put you at risk (somatic effects); and damage to your reproductive cells, which may put some of your descendants at risk (hereditary effects). There are many different somatic effects, but the most important long term effect is cancer.



Q. How can I tell if I'm being subjected to radiation?

A. Only by using appropriate instruments such as a Geiger counter, since none of our five senses of sight, hearing, touch, taste or smell enable us to detect ionising radiation.

Q. How are radiation doses measured, and what are thesafe limits?

A. Radiographers, workers in the nuclear industry and radiation workers in general wear a personal dosimeter to record their radiation doses.

The National Standard for limiting occupational doses requires that all doses should 'be kept as low as reasonably achievable' (ALARA), and that doses received by radiation workers should not exceed 20,000 μSv (about 14 times the average annual natural background in Australia) to the whole body in one year. The Australian Radiation Protection and Nuclear Safety Agency prescribes an annual dose limit for members of the public of 1,000 μSv. This is a dose that may result from the use of ionising radiation but does not include background radiation doses or doses you may receive from medical procedures.

The average annual radiation dose per person per year is approximately

1500 µSv

plus any exposure from medical procedures.

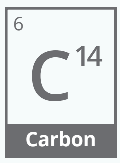
50 µSv +	**Travel and power stations -** such as air travel and coal-fired power stations.
300 µSv +	**Cosmic rays -** if you live 1000 metres above sea level add 200µSv – more if higher.
400 µSv +	**Food and drink -** mostly from naturally occurring radioactive potassium-40 and polonium-210. Some foods concentrate more radioactivity than others, although generally not enough to make a significant difference to this total.
800 µSv	**Terrestrial radiation -** long-lived radioactive materials like uranium and thorium occur in the environment. They emit ionising radiation that contributes 600 µSv a year to your average terrestrial radiation dose. This radiation comes from rocks and soils, and from building materials like bricks, mortar, concrete and tiles. radon and thoron are naturally occurring radioactive gases. Both these gases are present in the air you breathe. The major part of your average terrestrial radiation dose (200 µSv a year) therefore derives from the decay of radon and thoron in your lungs. In the open, these gases are diluted by the wind mixing them in the atmosphere. Indoors they may concentrate in still air.

Deduct **10%**	if you live in a wooden house.
Deduct **20%**	if you live in a tent
Deduct **50%**	or more if you live in the open
Add **10%**	or more if you live in a granite building
Add **100%**	or more if you keep doors and windows shut.
Add **100%**	or more if you use bore water, especially in a hot shower. Because bore water has been underground, it contains radon that is released when the water emerges from the bore. The release is enhanced when the water is heated or divided into droplets; it is therefore most marked in a hot shower.

Typical doses received during various diagnostic X-ray examinations

X-rays (conventional)	
Chest	**20** µSv
Leg or foot	**20** µSv
Dental	**5-10** µSv
Skull	**70** µSv
Barium meal	**2500** µSv
Intestine	**3000** µSv
Mammography	**400** µSv
X-rays (computerised tomography)	
Routine head	**2600** µSv
Routine abdomen	**13000** µSv

Examples of alpha, beta and gamma emitters

α (alpha)	β (beta)	γ (gamma)
Americium-241	**Carbon-14**	**Technetium 99m**
		
Used in smoke detectors	Used in carbon dating	Diagnostic medical radio

Medical uses

Doses received by patients are classified separately because their exposures to radiation are justified on the grounds that such exposures pose a lesser threat to their welfare than does the risk of undiagnosed or untreated disease.

No limits are set for diagnostic or therapeutic radiation exposures except that they should be as low as possible after considering risk-benefit factors. In nuclear medicine, the doses from diagnostic procedures are typically in the range 1,000-10,000 µSv (average 3,300 µSv). Doses from X-ray studies are generally slightly less.

When a nuclear medicine examination is proposed for a pregnant woman, care is taken to ascertain that the examination is required for a medical condition that requires prompt therapy. For these diagnostic examinations, the risk to the mother of not performing the examination must be greater than the radiation risk to the foetus. If an examination is performed the risk to the mother and foetus is kept as low as possible.

Medical radiation sources

The average dose from medical procedures in Australia is about 800 µSv per person per year. Typical radiation doses for various medical procedures using radioisotopes are shown in for each procedure listed.

Bone scan	**4600** µSv
Thyroid scan	**2600** µSv
Lung scan (Ventilation and perfusion)	**2600** µSv
Liver scan	**1700** µSv
Kidney scan	**1400** µSv
Soft tumours	**40,000** µSv
X-rays	See page 9

All figures are based on data from Radiation Protection in Australasia, 2000

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